4. Tominaga Y., Akabayashi S. I., Kitahara T., Arinami Y. Air flow around isolated gable-roof buildings with different roof pitches: Wind tunnel experiments and CFD simulations. *Building and Environment*. 2015. Vol. 84. P. 204–213. https://doi.org/10.1016/j.buildenv.2014.11.012.
5. Ledo L., Kosasih P. B., Cooper P. Roof mounting site analysis for micro-wind turbines. *Renewable energy*. 2011. Vol. 36. Iss. 5. P. 1379–1391. ttps://doi.org/10.1016/j.renene.2010.10.030.
6. Abohela I., Hamza N., Dudek S. Effect of roof shape, wind direction, building height and urban configuration on the energy yield and positioning of roof mounted wind turbines. *Renewable energy*. 2013. Vol. 50. P. 1106–1118. https://doi.org/10.1016/j.renene.2012.08.068.

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EFFECT OF MAGNETIC FIELD ON OPTICAL DENSITY OF DISTILLED WATER

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Water is considered as the working fluid of wet steam turbine units. The importance of a purposeful change in the thermophysical properties of water used for energy needs is indicated. A reagent-free method (transverse magnetic field of permanent magnets) of influence on water is proposed. Literature data on currently available papers dedicated to the study of water properties is presented. It is shown that the mechanisms of influence of external physical fields on the physicochemical and thermophysical properties of water have not been elucidated as of now. It is emphasized that the properties of distilled water during exposure and after exposure to physical fields are even less studied. The currently existing contradictions between theoretical ideas about the properties of water and experimental results are considered. It was found that currently there are no correct methods and equipment capable of indicating changes in water properties in real time. As a solution, the equipment and method of analyzing the optical density of distilled water is proposed. The shortcomings of most existing experimental works on the study of the influence of physical fields on the optical density of water are analyzed. The requirements for devices intended for measuring the optical density of distilled water are formulated. A stand was made and experimental work on the study of the dependence of the optical density of distilled water on the induction of a magnetic field that affects it was carried out. It is proved that the magnetic field affects the optical density of distilled water in the infrared range of wavelengths both in the direction of increase (4.1%) and in the direction of decrease (1.7%) depending on the induction of the magnetic field and the speed of water flow through the working section of magnetization device. A hypothesis explaining the obtained result is proposed.

Keywords: *magnetic field, optical density, magnetic field induction, distilled water.*

Introduction

Water is the working fluid of wet steam turbine units. Its properties largely determine the design of the steam turbine and other elements of the wet steam turbine units to achieve maximum efficiency. The working body of the wet steam turbine unit in the liquid phase should have the lowest possible heat capacity, which brings the isobars in the T, S diagram as close as possible to the vertical, and its critical parameters to the maximum possible values. In this case, the thermal efficiency of the Rankine cycle will be quite high [1]. In the view of this, a purposeful change in the properties of the working fluid (in particular, the heat capacity) in the case of reagent or reagent-free exposure is of crucial importance.

The decrease in the heat capacity of water during the dissolution of various physical substances in it is clearly illustrated in the handbooks on the thermodynamic properties of solutions [2]. Based on this fact, at the end of the 70s of the 20th century, A. I. Kalina proposed a new thermodynamic cycle that involves the use of a mixture of ammonia and water as a working fluid. The advantages of such a combination are the exothermicity

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of the ammonia dissolution reaction in water, the low heat capacity of the ammonia solution, and the high endothermicity of ammonia desorption from the aqueous solution. According to the scientist, the cycle makes it possible to convert about 45% of the heat used to produce electricity, while the famous Rankine cycle converts about 35%. At the same time, the efficiency of electricity production in terms of fuel increases by 20–28% [3]. However, during the practical use of the Kalina cycle, a number of technical difficulties that increase the cost of implementing this idea arise.

Taking into account what has been said, the best both from an economic and an environmental point of view, in our opinion, is a reagent-free change in the properties of the working fluid of wet steam turbine units. One of the types of such influence is the magnetic field of permanent magnets.

Magnetic treatment of water systems in technology was used at the beginning of the twentieth century to prevent the formation of scale on the heating elements of steam engines and to influence the formation of crystals in supersaturated solutions [4]. Since the ease of use of this method was obvious, a large number of papers devoted to the study of this issue appeared.

Currently, all theoretical studies on this problem can be divided into two large groups:

1) the magnetic field affects impurities that are always present in water in different phase-dispersed states;

2) the magnetic field directly affects the water properties.

Experiments were carried out mainly on tap water or on specially prepared solutions [5, 6]. As for the study of the properties of distilled water during exposure and after exposure to physical fields, there is extremely little information about such experiments [7, 8]. Most likely, this is due to the lack of clear recommendations regarding the parameters of influence and the necessary measurable parameters of the water under study. Since in this paper we are dealing with distilled water, the hypotheses belonging to the first group must be considered with some caution in view of the fact that in any water, even the purest one, there are still foreign inclusions, although in minimal concentrations. In thermal power engineering, for example, the mechanism of the effect of a magnetic field on water is explained by the presence of ferromagnetic iron oxides in water, mainly magnetite, which is always present in water due to corrosion of pipes and other elements of water supply that lead to the formation of crystallization centers [5].

At the same time, theoretical physics gives a negative answer to the question of the possibility of impact of, for example, a relatively strong magnetic field with intensity of $\sim 10^5$–10^6 A/m, not to mention weak fields, on water [9]. This leads to the conclusion that the properties of water before and after being in the field should be unchanged. Meanwhile, there are many experimental works [10–13], the results of which prove a change in the main physicochemical characteristics (such as pH, specific electrical conductivity, redox potential, density, viscosity, surface tension, optical density, heat capacity, structure, etc.) of water as a result of the influence of physical fields of various nature, which persist for a relatively long time (several tens of minutes).

At the same time, the change in water properties that can be recorded with the help of measuring equipment, as a rule, does not appear immediately during the exposure of the field, but later, and the interval can change unpredictably. Based on this, in our opinion, the problem of reliable indication of the effect of external fields on water in the on-line mode is relevant. As an indicator, it is necessary to choose such a water parameter, the change of which, as a result, will lead to changes in all other properties. We believe that all known properties of water are determined by the size of its clusters and the ratio of the number of free molecules and molecules connected by hydrogen bonds in the cluster. As a method by which it is possible to establish a change in these parameters, an optical one is proposed, since now there are experimental data on the structure of water obtained through the use of optical methods. However, their hardware implementation and measurement methods do not allow achieving high speed and fairly high accuracy of results [14–17].

In our opinion, a common shortcoming of most existing experimental works on the study of the influence of physical fields on the optical density of water is that monochromatic emitters were used as a source of radiation. Because of this, the study of the optical density of water for different frequencies took place at different points in time. As a result, additional influencing factors were not taken into account, which inevitably led to an increase in the measurement error. Therefore, the question of the influence of physical fields on water, as well as on the nature of the changes that occurred as a result of this action, remains and requires further study.

The purpose of this paper is to develop a tool for operational indication of the effectiveness of the magnetic field.

Materials and methods

A broadband emitter was used as a radiation source in the paper, and a set of selective sensors, each of which has a maximum spectral sensitivity at a certain frequency, was used as a receiver. At the same time, it is not at all necessary to determine the numerical value of the optical density. It is enough to induce a change in the output signals of the optical sensors by changing the factors of external influence, keeping the temperature of the water under study constant from experiment to experiment.

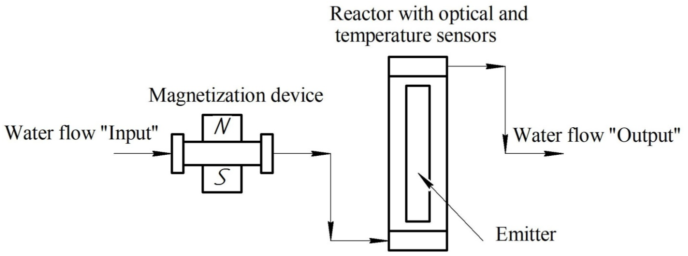

Fig. 1. Functional scheme of the stand

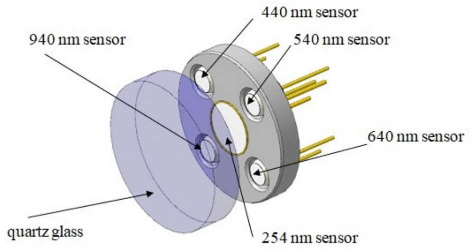

Fig. 2. Design of the optical sensor

For research, a stand developed and manufactured at IPMach of the National Academy of Sciences of Ukraine was used. Its functional scheme is shown in Fig. 1.

The stand is equipped with a measuring system consisting of the four temperature sensors of the water under study, a magnetic field induction sensor and five radiation intensity sensors. DS18B20 digital sensors were used as temperature meters. Such a large number of temperature sensors is explained by the significant influence of this parameter on all water properties, without exception. Sensors were placed evenly inside the reactor frame. Each subsequent experiment was carried out under the condition that the readings of the sensors deviated by no more than ±0.5 °C. To control the environment, the stand was equipped with a weather station that monitors the atmospheric pressure and temperature of the surrounding air.

Samplers are placed on the stand to ensure control of the physical and chemical parameters of water or its further treatment after physical exposure.

The optical sensor of the stand is equipped with five sensors with maximum spectral sensitivity in the following parts of the spectrum: 254; 440; 540; 640; 940 nm. The design of the sensor is shown in Fig. 2. An analog-to-digital converter was installed for each sensor in the control unit. The magnetization device available on the stand has a range of adjustment of magnetic induction within 0–540 mT.

This range was divided into twenty-seven discrete points, i.e., a step change in magnetic induction of 20 mT. A bactericidal ozone-free lamp PHILIPS TUV 30W 1SLV/25 was used as an emitter.

The obtained information was processed by a personal computer in real time with the possibility of constructing graphs of selected criterion parameters.

Magnetic induction was measured with an EM4305 tesla meter. Water consumption was determined by an LZS-25 rotameter.

Distilled water was passed through a magnetization device with a variable value of magnetic induction at a certain rate. Then the water entered the reactor with the emitter, where, after it was filled, the flow of water stopped. After achieving the minimization of internal water flows in the reactor, the information received from the optical sensors and temperature sensors of water in the reactor was recorded on the hard disk of the PC. The average value of the voltage at the output of each optical sensor during the observation period was chosen as an informative parameter. The temperature change in the reactor did not exceed 0.5 °C. The experiment was repeated three times for each value of magnetic induction and water flow rate. The results of three repetitions were averaged and considered as the result of one experiment.

Results and discussion

The results of experimental studies are shown in the graph (Fig. 3). Given that the optical sensors that were used are not calibrated in absolute units of optical density, the results are given in units of the voltage determined at the output of the sensors.

When processing the obtained data, it is necessary to take into account the fact that the voltage at the output of the sensors, strictly speaking, is not constant even if the extinction of electromagnetic waves by water is constant. This voltage varies within small limits (in this case ±0.5 mV) due to the presence of electrical noise, and it can also change due to chaotic movements of water masses as a result of local heating when the ultraviolet emitter is turned on. Therefore, the change in voltage at the output of the sensors within the limits of ±0.5 mV was not taken into account, and the output signal was considered unchanged. Studies have shown that the voltage at the output of the 254; 440; 540; 640 nm sensors does not change under any conditions of exposure to water. In the view of this, these results were excluded from further consideration. The graph shown in Fig. 3 contains information obtained exclusively by the 940 nm sensor.

The analysis of the obtained results showed that at water flows of 200 dm^3/h and 600 dm^3/h (this corresponds to the speed of water flow through the gap of the magnetization device of 1.1 m/s and 3.3 m/s, respectively) and magnetic field inductions of 80; 100; 240; 340–460 and 540 mT, the optical density of water in the infrared part of the spectrum changes significantly. Thus, only the 940 nm sensor showed a change in the output signal that is two to five times greater than the electrical noise voltage. The output voltage of all other sensors at all set water flows and magnetic field inductions did not exceed the noise, and it was not possible to detect a useful signal. On the graph shown in Fig. 3, it can be seen that the dependence of the output signal of the sensor on the induction of the magnetic field mainly has a polyextreme character. Moreover, for the two above-mentioned water flows, the change in the output signal of the sensor for the same induction of the magnetic field differs only by the magnitude of the noise signal. At inductions of 80; 100; 240 and 540 mT, an increase in optical density by 4.1% is observed (assuming that there is a linear dependence of the voltage at the sensor output on illumination), and in the range of inductions of 340÷460 mT we see a decrease in optical density by 1.7%. Range of 340–460 mT is interesting since the curve of the observed dependence has a fundamentally different form compared to other characteristic values of magnetic induction. In this case, the effect of polyextremity is violated, and the change in the value of the optical density changes its sign to the opposite one. The following can be chosen as a working hypothesis to explain the obtained effect: the change in optical density is associated with a change in the size and number of water clusters due to the influence of certain hydrodynamic factors (water flow speed) in combination with magnetic treatment.

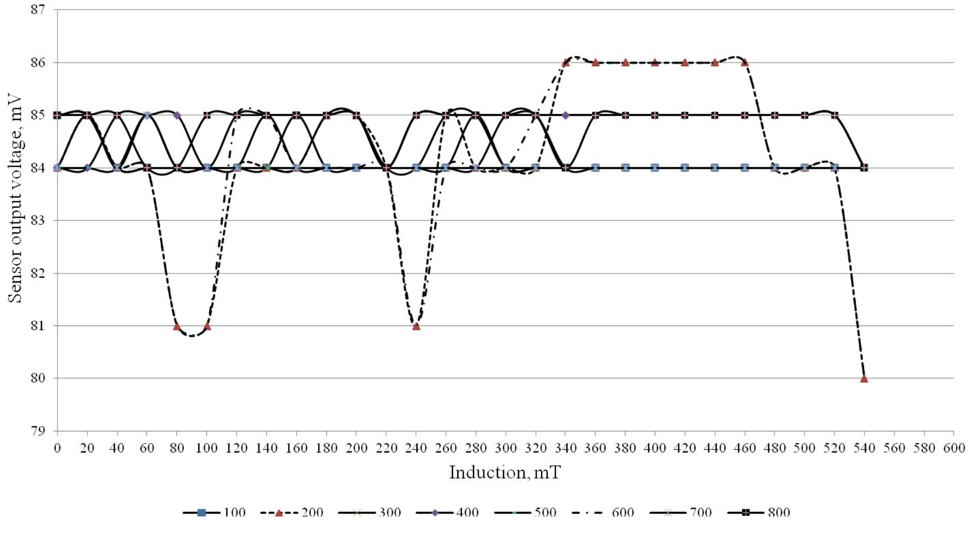

Fig. 3. Change in voltage at the output of the 940 nm sensor for different values of magnetic field induction and water consumption

Conclusions

The magnetic field undoubtedly affects the optical density of distilled water in the infrared range of wavelengths both in the direction of increase (4.1%) and in the direction of decrease (1.7%) depending on the induction of the magnetic field and the speed of water flow through the working section of the magnetization device. We believe that this effect is determined by a change in the size of water clusters, their number, and the ratio of the number of free molecules and molecules connected by hydrogen bonds into clusters.

A purposeful change in one of the physical properties of distilled water, namely optical density, should be accompanied by a change in all properties, including thermophysical ones. Based on this, the need to study changes in thermophysical parameters of water (heat capacity, heat of vaporization) under the influence of a transverse magnetic field is obvious.

By measuring the optical density of water in the infrared range of wavelengths, it is possible to talk about the optimal setting of the magnetization device in real time.

References

1. Krasnobryzhev, V. G. (2009) *Upravleniye teployomkostyu vody v teploenergetike* [Management of the heat capacity of water in the thermal power industry]. *Torsionnyye polya i informatsionnoye vzaimodeystviye* [Torsion fields and information interaction]: Proceedings of the International Scientific and Technical Conference, August 25–29, 2009, Khosta, Sochi. Moscow: Russian Academy of Natural Sciences, pp. 500–505 (in Russian).
2. Ravdel, A. A. & Ponomareva, A. M. (eds.). (2002). *Kratkiy spravochnik fiziko-khimicheskikh velichin* [Brief reference book of physical and chemical quantities]. St. Petersburg: Spetsial'naya literatura, 231 p. (in Russian).
3. Wang, E. & Yu, Z. (2016). A numerical analysis of a composition-adjustable Kalina cycle power plant for power generation from low-temperature geothermal sources. *Applied Energy*, vol. 180, pp. 834–848. https://doi.org/10.1016/j.apenergy.2016.08.032.
4. Kobe, S., Drazic, G., Mcguiness, P. J., & Strazisar, J. (2001). The influence of the magnetic field on the crystallisation form of calcium carbonate and the testing of a magnetic water treatment device. *Journal of Magnetism and Magnetic Materials*, vol. 236, iss. 1–2, pp. 71–76. https://doi.org/10.1016/S0304-8853(01)00432-2.
5. Wang, Y., Wei, H., & Li, Z. (2018). Effect of magnetic field on the physical properties of water. *Results in Physics*, vol. 8, pp. 262–267. https://doi.org/10.1016/j.rinp.2017.12.022.
6. Han, X., Peng, Y., & Ma, Z. (2016). Effect of magnetic field on optical features of water and KCl solutions. *Optic*, vol. 127, iss. 16, pp. 6371–6376. https://doi.org/10.1016/j.ijleo.2016.04.096.
7. Betskiy, O. V., Lebedeva, N. N., & Kotrovskaya, T. I. (2003). *Neobychnyye svoystva vody v slabykh elektromagnitnykh polyakh* [Unusual properties of water in weak electromagnetic fields]. *Biomeditsinskaya radioelektronika – Biomedical radio electronics*, no. 1, pp. 37–44 (in Russian).
8. Stas, I. Ye., Mikhaylova, O. P., & Bessonova, A. P. (2006). *Vliyaniye vysokochastotnogo elektromagnitnogo polya na fiziko-khimicheskiye svoystva distillirovannoy vody* [Influence of a high-frequency electromagnetic field on the physicochemical properties of distilled water]. *Vestnik Tomskogo gosudarstvennogo universiteta – Bulletin of Tomsk State University*, no. 62, pp. 43–51 (in Russian).
9. Davidzon, M. I. (1985). *O deystvii magnitnogo polya na slaboprovodyashchiye vodnyye sistemy* [On the effect of a magnetic field on weakly conductive water systems]. *Izvestiya vysshikh uchebnykh zavedeniy Ministerstva vysshego i srednego spetsial'nogo obrazovaniya SSSR. Fizika – News of higher educational institutions of the Ministry of Higher and Secondary Specialized Education of the USSR. Physics*, no. 4, pp. 89–94 (in Russian).
10. Malenkov, G. G. (2006). Structure and dynamics of liquid water. *Journal of Structural Chemistry*, vol. 47 (Suppl 1), S1–S31. https://doi.org/10.1007/s10947-006-0375-8.
11. Wang, Y., Zhang, B, Gong, Z, Gao, K., Ou, Y., & Zhang, J. (2013). The effect of a static magnetic field on the hydrogen bonding in water using frictional experiments. *Journal of Molecular Structure*, vol. 1052, pp. 102–104. https://doi.org/10.1016/j.molstruc.2013.08.021.
12. Cai, R., Yang, H., He, J., & Zhu, W. (2009). The effects of magnetic fields on water molecular hydrogen bonds. *Journal of Molecular Structure*, vol. 938, iss. 1–3, pp. 15–19. https://doi.org/10.1016/j.molstruc.2009.08.037.
13. Toledo, E. J. L, Ramalho, T. C, & Magriotis, Z. M. (2008). Influence of magnetic field on physical–chemical properties of the liquid water: insights from experimental and theoretical models. *Journal of Molecular Structure*, vol. 888, iss. 1–3, pp. 409–415. https://doi.org/10.1016/j.molstruc.2008.01.010.
14. Kovalenko, V. F., Levchenko, P. G., & Shutov, S. V. (2008). *Klasternaya priroda svetorasseyaniya vody* [Cluster nature of water light scattering]. *Biomeditsinskaya radioelektronika – Biomedical radio electronics*, no. 5, pp. 36–45 (in Russian).
15. Bunkin, N. F., Suyazov, N. V., & Tsipenyuk, D. Yu. (2005). Small-angle scattering of laser radiation by stable micron particles in twice-distilled water. *Quantum Electronics*, vol. 35, no. 2, pp. 180–184. https://doi.org/10.1070/QE2005v035n02ABEH002898.
16. Kovalenko, V. F., Bordyuk, A. Yu., & Shutov, S. V. (2011). *Opredeleniye formy klasterov vody* [Determination of the shape of water clusters]. *Optika atmosfery i okeana – Atmospheric and Oceanic Optics*, vol. 24, no. 7, pp. 601–605 (in Russian).
17. Nesteryuk, P. I. (2012). *Izmeritelno-vychislitel'nyy kompleks i metody issledovaniy fiziko-khimicheskikh parametrov vody posle vozdeystviya fizicheskikh poley* [Measuring and computing complex and methods for studying the physical and chemical parameters of water after exposure to physical fields]: Ph.D. dissertation. Polzunov Altai State Technical University, Barnaul, 19 p. (in Russian).

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Вплив магнітного поля на оптичну густину дистильованої води

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Розглянуто воду як робоче тіло паротурбінних установок. Позначена важливість цілеспрямованої зміни теплофізичних властивостей води, що використовується для потреб енергетики. Запропоновано безреагентний спосіб (поперечне магнітне поле постійних магнітів) впливу на воду. Наведено літературні дані про наявні в даний час роботи, присвячені дослідженню властивостей води. Показано, що на сьогоднішній день не з'ясовані механізми впливу зовнішніх фізичних полів на фізико-хімічні та теплофізичні властивості води. Наголошено, що властивості дистильованої води під час впливу і після впливу фізичних полів ще менш вивчені. Розглянуто наявні на сьогодні протиріччя між теоретичними уявленнями про властивості води та експериментальними результатами. З’ясовано, що натепер відсутні коректні методи й обладнання, здатне в режимі реального часу здійснювати індикацію зміни властивостей води. Як рішення запропоновано апаратуру і методику аналізу оптичної густини дистильованої води. Проаналізовано недоліки більшості наявних експериментальних робіт з вивчення впливу фізичних полів на оптичну густину води. Сформульовано вимоги до пристроїв, призначених для вимірювання оптичної густини дистильованої води. Виготовлено стенд і проведено експериментальні роботи з дослідження залежності оптичної густини дистильованої води від індукції магнітного поля, що на неї впливає. Доказано, що магнітне поле впливає на оптичну густину дистильованої води в інфрачервоному діапазоні довжин хвиль як у бік збільшення (4,1%), так і в бік зменшення (1,7%) залежно від індукції магнітного поля та швидкості потоку води через робочий переріз магнітного апарата. Запропоновано гіпотезу, що пояснює отриманий результат.

Ключові слова*: магнітне поле, оптична густина, індукція магнітного поля, дистильована вода.*

Література

1. Краснобрыжев В. Г. Управление теплоёмкостью воды в теплоэнергетике. Торсионные поля и информационное взаимодействие: материалы Международной научно-технической конференции, 25–29 августа 2009 г., Хоста, Сочи. М.: Российская академия естественных наук, 2009. С. 500–505.
2. Краткий справочник физико-химических величин / под ред. А. А. Равделя, А. М. Пономаревой. СПб.: Специальная литература, 2002. 231 с.
3. Wang E., Yu Z. A numerical analysis of a composition-adjustable Kalina cycle power plant for power generation from low-temperature geothermal sources. *Applied Energy*. 2016. Vol. 180. P. 834–848. https://doi.org/10.1016/j.apenergy.2016.08.032.
4. Kobe S., Drazic G., Mcguiness P. J., Strazisar J. The influence of the magnetic field on the crystallisation form of calcium carbonate and the testing of a magnetic water treatment device. *Journal of Magnetism and Magnetic Materials.* 2001. Vol. 236. Iss. 1–2. P. 71–76. https://doi.org/10.1016/S0304-8853(01)00432-2.
5. Wang Y., Wei H., Li Z. Effect of magnetic field on the physical properties of water. *Results in Physics.* 2018. Vol. 8. P. 262–267. https://doi.org/10.1016/j.rinp.2017.12.022.
6. Han X., Peng Y., Ma Z. Effect of magnetic field on optical features of water and KCl solutions. *Optic*. 2016. Vol. 127. Iss. 16. P. 6371–6376. https://doi.org/10.1016/j.ijleo.2016.04.096.
7. Бецкий О. В., Лебедева Н. Н., Котровская Т. И. Необычные свойства воды в слабых электромагнитных полях. *Биомедицинская радиоэлектроника.* 2003. № 1. С. 37–44.
8. Стась И. Е., Михайлова О. П., Бессонова А. П. Влияние высокочастотного электромагнитного поля на физико-химические свойства дистиллированной воды. *Вестник Томского государственного университета.* 2006. № 62. С. 43–51.
9. Давидзон М. И. О действии магнитного поля на слабопроводящие водные системы. *Известия высших учебных заведений Министерства высшего и среднего специального образования СССР. Физика*. 1985. № 4. С. 89–94.
10. Маленков Г. Г. Структура и динамика жидкой воды. *Журнал структурной химии.* 2006. Т. 47. Вып. 1. С. 1–31.
11. Wang Y., Zhang B, Gong Z, Gao K., Ou Y., Zhang J. The effect of a static magnetic field on the hydrogen bonding in water using frictional experiments. *Journal of Molecular Structure.* 2013. Vol. 1052. P. 102–104. https://doi.org/10.1016/j.molstruc.2013.08.021.
12. Cai R., Yang H., He J., Zhu W. The effects of magnetic fields on water molecular hydrogen bonds. *Journal of Molecular Structure.* 2009. Vol. 938. Iss. 1–3. P. 15–19. https://doi.org/10.1016/j.molstruc.2009.08.037.
13. Toledo E. J. L, Ramalho T. C, Magriotis Z. M. Influence of magnetic field on physical–chemical properties of the liquid water: insights from experimental and theoretical models. *Journal of Molecular Structure.* 2008. Vol. 888. Iss. 1–3. P. 409–415. https://doi.org/10.1016/j.molstruc.2008.01.010.

14. Коваленко В. Ф., Левченко П. Г., Шутов С. В. Кластерная природа светорассеяния воды. *Биомедицинская радиоэлектроника*. 2008. № 5. С. 36–45.
15. Бункин Н. Ф., Суязов Н. В., Ципенюк Д. Ю. Малоугловое рассеяние лазерного излучения на стабильных образованиях микронного масштаба в дважды дистиллированной воде. *Квантовая электроника*. 2005. Т. 35. № 2. С. 180–184.
16. Коваленко В. Ф., Бордюк А. Ю., Шутов С. В. Определение формы кластеров воды. *Оптика атмосферы и океана*. 2011. Т. 24. № 7. С. 601–605.
17. Нестерюк П. И. Измерительно-вычислительный комплекс и методы исследований физико-химических параметров воды после воздействия физических полей: автореф. дис. … канд. техн. наук: 01.04.01 / Алтайский государственный технический университет имени И. И. Ползунова, Барнаул, 2012. 19 с.

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CRITERION BASIS FOR ASSESSMENT OF TRANSPORT AIRCRAFTS MODIFICATIONS BY COST INDICATORS

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The subject of research in the paper is the process of forming a criterion base to evaluate the effectiveness of carrying out modification changes in a transport category aircraft. The goal is to develop supporting criteria for making decisions regarding the expediency of modification changes, namely, during design, during production, and at the stage of its operation, at each stage of the life cycle of a new transport category aircraft. The complexity of the task lies in the need to develop a model for evaluation of the consequences of changing the aircraft for each stage separately, which would collectively determine the integral effectiveness of its modification. To evaluate the efficiency of basic aircrafts in operation, there are a number of economic indicators of their efficiency, in particular, the cost of an aircraft hour and the transportation of one ton of cargo per one kilometer, which are only partially taken into account when analyzing the efficiency of aircraft modifications, although in the case of aircraft transport category, specific cost criteria for the entire life cycle both for the base aircraft and for its modification is required. For their development, a method of estimating the cost of the entire life cycle of the aircraft is proposed, as well as a method of dividing modification changes according to the parameters of the upper level (PMD), which is used at the stage of designing the devices, and the lower level (PPO) for the operational stage. On the basis of and taking into account the specifics of the specified methods, indicators of additional labor costs that arise during the implementation of modification changes in the conditions of production and at the stage of aircraft operation have been developed. The proposed criteria take into account indicators of the transport efficiency of heavy aircraft modifications and the integral efficiency of the modification, taking into account the costs at all the main stages of the life cycle of the modification. The scientific novelty of the obtained results is as follows: the supporting criteria for the adoption of decisions regarding the expediency of modification changes at each stage of the life cycle of a new transport category aircraft are proposed, i.e. during design, under the conditions of production and at the stage of its operation. Such criteria will ensure the integral efficiency of the transport aircraft modification.

Keywords: *transport aircraft; base aircraft, aircraft modifications; aircraft efficiency assessment models.*

Introduction

The process of creating modifications of transport aircrafts of all weight categories has developed widely. On the basis of the changes, the problem of continuously improving the productivity (flight and hour one) of this type of aircrafts is solved.

This goal can be achieved by increasing three parameters: commercial load m_{cl}, distance of transportation L and cruising speed V_{cruise}.
